than it would have been a few years ago, and altogether the book is a valuable contribution to the science of education. A useful bibliography is appended.

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NOTES ON THE TEACHING OF ZOOLOGY AND PLANS FOR ITS IMPROVEMENT

Few Elect Zoology.—Although for some time the writer has been under the impression that a good many more students elect botany than zoology, both in the high schools and academies and in the college; yet in glancing over our (Kansas) "High School Manual"[1] I was somewhat surprised to find that almost *eight* times as many high school pupils were last year enrolled in botany as in zoology—to be exact, 2,669 in botany and 346 in zoology. Another table in this manual reveals the fact that while 177 of the accredited high schools claim to be equipped for botany, but 33 claim any equipment for zoology, and the latter is usually estimated at a lesser value. I can quote figures from one other state only. In Minnesota,[2] starting with a ratio of 4 to 1 in 1894, zoology has steadily gained till last year it stood 9 to 7 in favor of botany. The fact that neither St. Louis, Mo., nor Tacoma, Wash., offers any zoology in its high schools leads me to suspect that similar disproportion exists in other states, at least in the middle and far west.

We teachers of zoology can not avoid asking, Why is this so? It is surely not because animals with their free movements and their intelligence are less interesting than plants. Where is the child or grown-up (aside from the specialist) who will not leave the prettiest bed of flowers to watch the cage of playful monkeys? The moving object, particularly the automatically moving one, attracts all of us. Nor can it be that the school authorities regard zoology as less practical than botany. To know the ravaging insect is just as important as to recognize the medicinal plant. To name the brilliant song bird properly is just as desirable as to classify the fragrant flower.

According to my thinking, at least three causes can be cited which operate to bring about such a disproportion between the subjects.

The first one is the lack of properly prepared teachers. Few of the instructors in the high schools are prepared to teach either of the two sciences. When called upon to teach one, a majority will choose botany instead of zoology. They probably had a course in elementary botany and not in zoology. Besides, plants are simpler and they feel that they can manage a course concerning them better than the more complex and larger group of animals.

A second and probably a more potent cause is the fact that many of our children are taught by their parents from early childhood to avoid and fear the animals—the creepy worms, the biting spiders and the dreadful mice. In "nature study" in the grade schools (taught by women) this view of the animals is farther inculcated. As a result, when the young people get into the high school and are to select a biological science they naturally choose botany.

The third cause is a greater one, at least a more real one. It is the difficulty of securing plenty of good material for the course in zoology. While the botanist has all his important phyla represented in almost any inland region, the zoologist has three important phyla practically limited to salt water. This necessitates the securing of a good deal of material from the seashore. And of the material that is in the vicinity it is so much easier for the botanist to secure what he wants—to pick the flower on the bank of the brook than to catch the cray-fish in the dirty water. The flower will surely be found on the first "tramp," provided it is made at the right time and to the right place. To secure the cray-fish, in addition to choosing the right season and the proper locality, the necessary seine or other paraphernalia to catch the desired specimen must be taken along. Sometimes it means the employment of help to handle the apparatus. To secure some species requires a different set of tools, and they are even harder to get than

[1] *Bulletin of the University of Kansas*, 1908.

[2] Fifteenth Annual Report of the Inspector of the State High Schools. State of Minnesota, 1908.

the cray-fish. After the material has been brought to the laboratory it needs to be killed and preserved by proper methods. All this means more trouble than the ordinary high-school teacher wants to or has time to take.

It is true some specimens can be bought; and matters are rapidly improving as more collectors are selling zoological supplies; yet not all the things needed are on the market. Many of those who would teach zoology do not know where to buy. The cost, which is considerable, hinders some. Besides, teachers feel that a good many local forms should be studied, and this is true especially in the high school. But where and how shall they be secured?

University a Distributing Center.—To answer the last question and encourage zoology teaching over the state the department of zoology in the University of Kansas has decided to become a central supply station for the secondary schools of the state. Many of the standard type-forms have been purchased in larger quantities than needed for the department's own use. A good deal of local collecting has been done; besides, two expeditions have been taken, one to the Gulf Coast in 1908, and one to Puget Sound in 1909. On both of these trips, but especially the latter, large quantities of material were secured for class use. This has been carefully prepared and preserved for dissection and demonstration. All these collections put the department in shape to supply all the necessary material to the secondary schools. A preliminary list of what can be furnished has been sent to the schools. Prices are very low, because of the excellent collecting found on the coast of Puget Sound, and because the plan of the department is not to make money out of the venture, but to get more zoology taught. So as not to discourage small schools, small orders are sold at nearly as low prices as larger ones. The result of the whole plan is and will continue to be to encourage and improve greatly the zoology teaching in our preparatory schools.

"Problem Solving."—The writer believes that one important thing in teaching is to get the student to "solving problems." Professor Alexander Smith has recently emphasized this very much in the columns of this JOURNAL.[3] With this in view the writer has for five years assigned to every member of the classes in the second and third courses in zoology one major problem to be worked out and reported on before the class. The question to be reported on was always so chosen that it could not be answered from any book, but required independent dissection and observation. The subject was assigned early in the semester so that the student had ample time to work it out in addition to the daily work in the class room. This has always given satisfactory results.

During the last two years our department has used in elementary zoology such a scheme of "problem solving" that seems to me to be worthy of a trial by other teachers. Our elementary classes are large, running from 75 to 100 or more students. After the type form for the phylum or class is done other species of the group are classified by the student as far as the order. For this purpose we have regular sets of bottled and numbered specimens which are given to a small section of the class and these students classify them, giving the reason for, or the characteristic used in, every determination. Similar sets are being prepared for the high schools, either to be sold or loaned to them.

After all the principal phyla have been studied every student, as far as possible, is given a different animal. He finds out what the specimen is, dissects it, makes drawings of it and in short finds out all he can about it, and then reports his findings to the rest of the class. As most of these specimens are but briefly if at all described in the usual texts used, the problem is a real one to the student. He is urged and must of necessity get first-hand knowledge by comparing his specimen with the forms already studied. Only after he has found all he can is he guided to additional literature. By this plan the student solves a real problem. He learns to notice in a new way how the "types" are treated in the text-books so as to get a plan for the arrangement of his own material. This plan must be approved by one of the instructors before the report can be given to the class. While one stu-

[3] SCIENCE, N. S., XXX., p. 459.

dent reports the rest take notes, just as they do when the instructor lectures. At the end of each report questions are asked and corrections are made. The notes taken by the rest of the students are corrected by the one who gives the report, and are bound up with the students' general note-book for the course. The one reporting binds up his outline, and a list of the books and papers consulted—a bibliography.

By this plan the student learns much about one animal not treated in the texts and he learns a little about a good many other species. But he does more—*he gets a training in using the powers of observation, in ordering the facts obtained and in expressing to others the knowledge gained.*

The two main suggestions are worth a trial by other teachers. The university should encourage the teaching of zoology by becoming a center for furnishing and distributing the material for the preparatory schools of a state at cost. Much of this could be secured very cheaply by a collecting expedition to Puget Sound. The student should be given the problem of furnishing the rest of the class with a report dealing with a special form of animal life somewhat closely related to a type studied. This working out of a "lecture?" by the student is the best of training for him.

W. J. Baumgartner

SPECIAL ARTICLES

AN EXPRESSION FOR THE BENDING MOMENT AT ANY SUPPORT OF A CONTINUOUS GIRDER FOR ANY NUMBER OF EQUAL SPANS

Tables giving the bending moments at the supports of a continuous uniformly loaded girder with equal spans are found in most of the books on strength of materials, but these tables usually stop at six or seven spans. The object of this paper is to give a general expression from which the bending moment at any support for any number of spans can be computed. First the expression and explanation of the method of computation are given and then follows the derivation of the formula.

Let M_1, M_2, $\cdots$ be the bending moments at the first, second ... support, respectively. Let n be the number of spans, w the load per unit length and l the length of span. If M_r represents the bending moment at the rth support then the formula gives

$$M_r = -\frac{\Delta_{r-2}D_{n-r+1} - D_{r-2}\Delta_{n-r}}{2\Delta_{n-1}} wl^2.$$

The Δs and Ds are numbers to be computed from the formulas.

$$\Delta_n = 4\Delta_{n-1} - \Delta_{n-2},$$
$$D_n = \Delta_{n-1} - D_{n-1}.$$

As shown below, $\Delta_0 = 1$, $\Delta_1 = 4$ and $D_0 = 0$ and any other Δ or D may be easily computed. For example,

$$\Delta_2 = 4\Delta_1 - \Delta_0 = 15,$$
$$\Delta_3 = 4\Delta_2 - \Delta_1 = 56,$$
$$\cdots\cdots\cdots$$
$$D_1 = \Delta_0 - D_0 = 1,$$
$$D_2 = \Delta_1 - D_1 = 3.$$

Thus, if, for example, we wish the bending moment at the fourth support for seven spans, we have $r = 4$, $n = 7$ and

$$M_4 = -\frac{\Delta_2 D_4 - D_2\Delta_3}{2\Delta_6} wl^2.$$

From the above formulas $\Delta_2 = 15$, $D_4 = 44$, $D_2 = 3$, $\Delta_3 = 56$, $\Delta_6 = 2911$. Hence

$$[M_4]_{7\ \text{spans}} = -6/71\, wl^2,$$

a result which is verified by the tables.

The derivation of the above formula is nothing but the general solution of the equations of three moments by determinants. For n spans we have, from the theorem of three moments,

$$M_1 + 4M_2 + M_3 = -wl^2/2,$$
$$M_2 + 4M_3 + M_4 = -wl^2/2,$$
$$\cdots\cdots\cdots\cdots$$
$$M_{n-1} + 4M_n + M_{n+1} = -wl^2/2.$$

Since $M_1 = M_{n+1} = 0$ we have left $n-1$ equations with $n-1$ unknowns. If we write 1 in place of $-wl^2/2$ and multiply the final result by $-wl^2/2$ the solution will be less complicated. Writing the Ms with the same subscripts under one another we have

$$\begin{aligned} 4M_2 + M_3 \qquad\qquad &= 1,\\ M_2 + 4M_3 + M_4 \qquad &= 1,\\ M_3 + 4M_4 + M_5 &= 1,\\ \cdots\cdots\cdots\cdots \end{aligned}$$

The determinant of the system of equations will be the determinant,